4(d) RULE EVALUATION AND RECOMMENDED DETERMINATION

FMEP SUBMITTED BY: Washington Department of Fish and Wildlife

FISHERIES OR AREA: Washington freshwater fisheries potentially affecting listed Lower Columbia River chinook salmon, chum salmon and steelhead.

EVOLUTIONARILY SIGNIFICANT UNIT (ESU): Lower Columbia River chinook salmon *(Oncorhynchus tshawytscha*)
Columbia River chum salmon (*Oncorhynchus keta*)
Lower Columbia River steelhead (*Oncorhynchus kisutch*)

4(d) RULE LIMIT: Limit 4

TRACKING NUMBER: NWR/4d/04/2001/012

DATE:

The Washington Department of Fish and Wildlife (WDFW) has submitted a Fisheries Management and Evaluation Plan (FMEP) for Washington commercial and recreational freshwater fisheries potentially affecting listed chinook salmon, chum salmon, and steelhead in the Lower Columbia River basin (WDFW 2003). This plan was submitted for National Marine Fisheries Service (NMFS) approval under limit 4 of the anadromous fish 4(d) Rule (50 CFR 223.203(b)(4); July 10, 2000, 65 FR 42422).

EVALUATION

The 4(d) Rule for the Lower Columbia River (LCR) chinook salmon, chum salmon, and steelhead ESUs states that the prohibitions of paragraph (a) of the rule do not apply to fishery harvest activities provided that:

- Fisheries are managed in accordance with a NOAA Fisheries approved FMEP, and
- Fisheries are implemented in accordance with a letter of concurrence from NOAA Fisheries.

NOAA Fisheries can approve an FMEP if it adequately addresses the criteria specified below. The following is an evaluation of whether the submitted FMEP adequately addresses the criteria

for limit 4 of the 4(d) Rule for Lower Columbia River chinook salmon, chum salmon, and steelhead.

Limit 4 Criteria and FMEP Evaluation

Clearly defines its intended scope and area of impact

This FMEP addresses all non-Indian freshwater recreational and commercial fisheries that affect or could potentially affect Washington populations of LCR spring and fall chinook salmon, chum salmon, and summer and winter steelhead in the mainstem and Washington tributaries of the Lower Columbia River, excluding those mainstem Columbia River fisheries managed under *U.S. v. Oregon*. Ocean fisheries targeting these ESUs undergo section 7 consultation initiated by the Pacific Fisheries Management Council, and the mainstem Columbia River fisheries undergo section 7 consultation initiated by the parties to *U.S. v. Oregon*. The Lower Columbia Management Area (LCMA) is described in section 1.2.1 of the FMEP and in Figure 1 below.

Sets forth the management objectives and the performance indicators for the plan

The LCR FMEP is based on WDFW's Wild Salmonid Policy. In that policy, it states that harvest rates will be managed so that (1) spawner abundance levels abundantly utilize available habitat, (2) ensure that the number and distribution of locally adapted spawning populations will not decrease, (3) genetic diversity within populations is maintained or increased, (4) natural ecosystem processes are maintained or restored, and (5) sustainable surplus production above levels needed for abundant utilization of habitat, local adaptation, genetic diversity, and ecosystem processes will be managed to support fishing opportunities (WDFW 1997). In addition, fisheries will be managed to ensure that adult size, timing, distribution of the migration and spawning populations, and age at maturity are the same between fished and unfished populations. By following this policy, fisheries' impacts on listed chinook salmon, chum salmon, and steelhead in the LCR ESUs will be managed to support the recovery of these species and will not jeopardize their survival and recovery.

The performance indicators for the management objectives of the LCR FMEP are fully described in sections 1.1.1 and 3.1 of the LCR FMEP. To summarize, the performance indicators include fish population indicators and fishery indicators. Fish population monitoring activities for adult steelhead and salmon abundance include:

- **Redd surveys** that are conducted for winter steelhead in the SF Toutle, Coweeman, EF Lewis, and Washougal Rivers. Redd surveys are also conducted in the Cowlitz River for fall and spring chinook.
- **Mark-recapture** surveys provide data for summer steelhead populations in the Wind and Kalama Rivers.
- **Mark-recapture carcass surveys** are conducted to estimate populations of chinook salmon in Grays, Elochoman, Coweeman, SF Toutle, Green, Kalama, NF Lewis,

EF Lewis, Rivers and Skamokawa, Mill, Abernathy, and Germany Creeks and for all chum salmon populations.

- **Snorkel surveys** are conducted for summer steelhead in the EF Lewis, Washougal and Wind Rivers.
- **Trap Counts** are conducted on the Cowlitz, NF Toutle, Kalama, and Wind Rivers and on Cedar Creek a tributary of the NF Lewis River.
- **Area-Under-the-Curve (AUC)** surveys are conducted to collect population data for chum salmon in Grays River and Hardy and Hamilton Creeks.All sampling of carcasses and trapped fish include recovery of coded-wide-tagged (CWT) fish for hatchery or wild stock evaluation.
- **Downstream migrant trapping** occurs on the Cowlitz, Kalama, NF Lewis, and Wind Rivers, Cedar Creek, and will expand to other basins as part of a salmonid life cycle monitoring program to estimate freshwater production and wild smolt to adult survival rates.

Performance indicators for fisheries include estimates of catch, catch rate, harvest, harvest rate, hooking mortality, effort, and catch per unit effort (CPUE). Biologists use creel surveys, catch record cards (CRC), and follow-up phone surveys to estimate these performance indicators. Fishery indicators for mainstem Columbia River commercial fisheries include total poundage landings, which are solicited in phone surveys in-season and reported on fish receiving tickets. Commercial fishery catch composition and average weight information are obtained by subsampling a portion of the catch at commercial fish buyer sites.

In addition, NOAA Fisheries evaluates whether the FMEP adequately addresses the following criteria:

4(i)(A) Defines populations within affected ESUs, taking into account: spatial and temporal distribution, genetic and phenotypic diversity, and other appropriate identifiably unique biological and life history traits.

Located within the LCMA (Figure 1), are three affected ESUs. The FMEP defines the populations with the affected ESUs. The population designations in the FMEP are consistent with the preliminary population designations developed by the Willamette/Lower Columbia Technical Recovery Team (TRT) (Myers *et al.* 2002). The FMEP adequately defines populations within the affected ESUs in section 1.3.1, as summarized here.

Spring Chinook Salmon

Spring chinook salmon are native to the Cowlitz and Lewis Rivers. It is unclear if spring chinook salmon were historically present in the Kalama River. Native populations are believed to have been extirpated from the Lewis River. The current status of wild spring chinook salmon populations in the Cowlitz and Kalama Rivers is unknown. Spring chinook salmon were not native to the Deep, Wind, or Little White Salmon Rivers, and hatchery releases into these basins

are strictly for harvest. WDFW has ongoing research/recovery programs for spring chinook salmon in the Kalama and Cowlitz Rivers.

Fall Chinook Salmon

All medium to large tributaries in the LCMA had native populations of fall chinook salmon. Tule fall chinook salmon are present in almost all basins. These fish enter earlier and are more mature than other LCMA fall chinook salmon stocks. Tule fall chinook salmon are produced at the Elochoman, Sea Resources, Cowlitz, Toutle, Kalama, and Washougal hatcheries and at the Spring Creek National Fish Hatchery. The tule fall chinook salmon programs have been substantially reduced due to Mitchell Act funding reductions in the mid-1990s. Coded-wire-tag recovery analyses have found that less than 10% of the natural spawning tule fall chinook salmon in the Mill Creek, Germany Creek, and Coweeman, SF Toutle, EF Lewis, NF Lewis, and Wind River basins are hatchery fish. Naturally produced bright fall chinook salmon are found primarily in the Lewis River. These fish enter later and are less mature than tule fall chinook. Genetic analysis supports differences between tule and bright races of fall chinook salmon. Non-LCR chinook ESU upriver bright fall chinook are released at the Little White Salmon NFH.

Chum Salmon

WDFW has identified two population centers for chum salmon near the Grays River and below Bonneville Dam. The Grays River population consists of fish spawning in the mainstem Grays, WF Grays, Crazy Johnson, and Gorley subbasins. The below-Bonneville Dam population consists of fish spawning in the mainstem Columbia River adjacent to Ives Island, in Hardy Creek, and in Hamilton Creek. These group also includes recently observed spawning groups in Duncan Creek and near the I-205 bridge. Other basins where chum salmon have been observed include: Skamokawa, Elochoman, Mill, Abernathy, Germany, Cowlitz, Lewis, Washougal, small independent Columbia Gorge tributaries, and the Columbia River above Bonneville Dam. It is unclear if the spawners in these other basins are separate populations and self-sustaining, due to the lack of genetic and population data. Hatchery chum salmon are currently being raised at Grays River and Sea Resources hatcheries as part of a recovery plan for lower Columbia River tributaries in the LCMA. Chum salmon are also reared at the Washougal Hatchery to support chum re-introduction into Duncan Creek.

Steelhead

Winter steelhead are native to all major and most minor basins in the LCMA. Within the LCR steelhead ESU, hatchery steelhead are produced and released into the Cowlitz, Coweeman, Kalama, Lewis, and Washougal River basins and Salmon Creek. Self-sustaining populations exist in all tributaries but may be absent in parts of the Cowlitz and Lewis Rivers. Large hatchery programs in these basins were developed to mitigate for the loss of access to the most productive steelhead habitat due to the construction of dams. Due to the magnitude of hatchery spawners and the duration of the programs, wild steelhead population abundance and wild steelhead genetic composition are unknown in these basins, but the late-run winter steelhead are considered to be part of the listed populations. Steelhead in tributaries below the mouth of the

Cowlitz River are in the SW Washington ESU and are not listed under the ESA. In this area, hatchery steelhead are released into the Grays and Elochoman Rivers.

Summer steelhead are native to the Kalama, Lewis, Washougal, and Wind River basins. Wild summer steelhead populations are still present in these basins. Hatchery summer steelhead are planted in the Cowlitz, Toutle, Green, Kalama, Lewis, and Washougal Rivers. Summer steelhead are reproductively isolated from winter steelhead by differences in spatial and temporal distribution.

Further information on the population structure throughout the LCR ESUs can be found in section 1.3.2 of the FMEP, "Description of the current status of each population relative to its Viable Salmonid Population thresholds."

All of the other listed ESUs in the Columbia basin are either not affected by the fisheries included in this FMEP or impacts from the fisheries will be addressed in other FMEPs or section 7 consultations (Table 1). These ESUs include Upper Willamette River spring chinook salmon and steelhead; Snake River spring/summer chinook salmon, fall chinook salmon, sockeye salmon, and steelhead; Upper Columbia river steelhead and spring chinook salmon; and Middle Columbia River steelhead.

Table 1. Status of ESA coverage for fisheries occurring in the Lower Columbia River management area. Impacts of mainstem Columbia River fisheries affecting all upriver ESUs not listed in the table are addressed in the section 7 consultation on mainstem fisheries (NMFS 2000a). The impacts of ocean fisheries on all listed Columbia Basin ESUs are addressed in section 7 consultations with Pacific Fishery Management Council (NMFS 2000b).

Area / ESU	Process for ESA Coverage	Status
Ocean fisheries	Section 7 consult.	Completed (April 2001)
Mainstem Columbia River fisheries	Section 7 consult.	Completed (March 2001)
Lower Columbia chinook		
Oregon tributary fisheries	FMEP	In review
Washington tributary fisheries	FMEP	In review
Lower Columbia steelhead		
Oregon tributary fisheries	FMEP	In review
Washington tributary fisheries	FMEP	In review
Columbia chum	FMEP	In review
Upper Willamette spring chinook	FMEP	Completed (Feb. 2001)
Middle Columbia steelhead		
Oregon tributary fisheries	FMEP	In review
Washington tributary fisheries	FMEP	In review
Upper Willamette steelhead	FMEP	Completed (Nov. 2001)

4(i)(B) Uses the concepts of ‘‘viable’’ and ‘‘critical’’ salmonid population thresholds, consistent with Viable Salmonid Populations (VSP) concepts in “Viable Salmonid Population.”

The regulations in the 4(d) Rule state that an FMEP must use the concepts of “viable” and “critical” thresholds in a manner so that fishery management actions: (a) recognize significant differences in risk associated with viable and critical population threshold states; and (b) respond accordingly to minimize long-term risks to population persistence. Harvest actions that impact populations at or above viable threshold must maintain the population or management unit at or above the viable level. Impacts on populations above critical levels but not at viable levels (demonstrated with high degree of confidence) must not appreciably slow achievement of viable function. Impacts on populations functioning at or below critical threshold must not appreciably

increase genetic and demographic risks facing the population and must be designed to permit achievement of viable functions, unless the FMEP demonstrates the likelihood of survival and recovery of the entire ESU in the wild would not be appreciably reduced by greater risks to an individual population.

NOAA Fisheries' "Viable Salmon Populations and Recovery of ESUs" document describes four key parameters for evaluating the status of salmonid populations (McElhany *et al.* 2000). These parameters are population size (abundance), population growth rate (productivity), spatial structure, and diversity. NOAA Fisheries provides limited guidance on fish numbers corresponding to critical and viable thresholds. McElhany *et al.* (2000) discuss hypothetical risks related to genetic processes effective at annual spawning population ranging from 50 to several thousand individuals. The NOAA Fisheries' VSP guidelines include multiple warnings about the effects of uncertainty in population assessments and also recommend an adaptive management approach for reducing uncertainty (McElhany *et al.* 2000). WDFW did not develop interim critical thresholds because biological information is limited to a few index populations and because the VSP thresholds are currently being developed by the Willamette/Lower Columbia Technical Recovery Team (TRT).

Definition of an appropriate viable threshold depends largely on the capacity and productivity of the available habitat and the corresponding population size where compensatory population processes begin to provide resilience. Habitat capacity and productivity are estimated for Lewis River fall chinook salmon and Kalama River steelhead populations using time series data of spawners and recruits. However, estimating productivity in other basins is difficult due to the lack of suitable population data or knowledge of hatchery effects. Changes in hatchery practices and the institution of appropriate monitoring programs are expected to provide the necessary information in the future, but preliminary estimates of productivity and capacity will require a minimum of ten years of age-specific escapement data in addition to the data already collected.

Even without the establishment of VSP thresholds, the fishery management plan focuses primarily on maintaining harvest rates that do not appreciably reduce the probability of survival and recovery. Periodic poor cohorts are inevitable but an extended sequence of poor survival should trigger consideration of more conservative management strategies, and this consideration should be tied to fish numbers. Lower cohort survivals are expected at very large escapements because the available habitat can be overseeded. Poor replacement rates under these conditions should not trigger a conservative management response. To reduce the likelihood of this happening, WDFW proposed to implement harvest regimes that are based on the lowest survivals to ensure adequate levels of escapement are available even during the least productive years.

Harvest of salmon and steelhead in the LCMA is managed to meet wild salmon and steelhead escapement objectives and to meet the objectives of artificial propagation programs. To manage harvest to meet these goals, WDFW has developed escapement objectives for all hatchery populations and some wild populations (Table 2). Interim maximum harvest rates have been

established for the remaining wild stocks. These rates are less than the estimated maximum sustainable yield (MSY) harvest rates under low ocean productivity or the Recovery Exploitation Rates (RERs) developed by NOAA Fisheries for the Pacific Fisheries Management Council (PFMC) (NMFS 2000b). Fishing seasons are then established based on a forecast of salmon and steelhead returning to the LCMA. In years where run size to the tributaries is forecast to be below escapement requirements, harvest in tributaries is reduced or eliminated to limit catch and release mortality of wild fish. Harvest reductions are accomplished by time and area closures, gear restrictions, or changes in the daily catch limits. When forecasts are not made, conservative harvest rates are established. Natural fall chinook salmon may be retained in the LCMA. Harvest impacts allowed by WDFW under the FMEP will be determined by hatchery escapement goals and are tailored through season timing, area openings, and bag limits to ensure that impacts from the fisheries in this FMEP do not exceed the RERs developed by NOAA Fisheries. These RERs address impacts for all fisheries combined (ocean, mainstem Columbia, and tributaries). The RERs are periodically revised, and management under this FMEP will adopt any updated RERs as new management thresholds.

To the extent possible, WDFW uses selective fisheries to maximize harvest rates on hatchery stocks while protecting and/or rebuilding wild stocks. Selective fisheries for spring chinook salmon have been implemented in the Cowlitz, Kalama, and Lewis Rivers (the spring chinook salmon returning to the Wind River, the Big White Salmon River, and Drano Lake are hatchery returns, therefore retention of unmarked spring chinook salmon is permitted). The entire LCMA is selective for marked hatchery steelhead and the retention of unmarked steelhead is prohibited. The retention of chum salmon in all tributaries fisheries is prohibited. Impacts on listed natural spring chinook salmon, chum salmon and steelhead will depend on the encounter rate of natural fish in the fisheries, the associated catch and release mortality, and illegal harvest (which is estimated to be less than 1.5%).

As described above, if returns are expected to be below escapement requirements (Table 2), fisheries in those tributaries will be reduced or eliminated. The escapement requirements that are currently in place will be modified, if necessary, when the TRT establishes critical thresholds for the populations in the LCR ESUs and through recovery planning. No changes to the selective harvest regime for spring chinook salmon and steelhead are proposed if the populations reach viable threshold levels set by the TRT. The requirement that all natural spring chinook salmon in the Cowlitz, Kalama and Lewis Rivers and steelhead in the LCMA that are caught be released unharmed will remain in effect. This approach is innovative for chinook salmon fisheries. In the past, fishery impacts have tended to increase substantially when abundance increases. The selective fishing regime in the LCMA will allow for larger escapements of natural fish during years of large run sizes, which are needed to explore stock productivity and habitat capacity.

Table 2. Management goals for the Lower Columbia Management Area. Broodstock goals from HGMPs and Escapement goal from SASSI (WDF *et al.* 1993). Escapement goals will be updated through recovery planning.

Spring Chinook management goals for basins in the LCMA.			
River Basin	**Hatchery**	**Broodstock Goal**	**Natural Escapement**
Cowlitz River	Cowlitz Salmon	1,724	No established goal.
Kalama River	Kalama Falls	300	500
Lewis River	Lewis River	800	No established goal.
Wind River	Carson NFH	1,400	No natural spawning
Little White Salmon	Little White Salmon NFH	900	No habitat available
Fall Chinook management goals for basins in the LCMA.			
Chinook River	Sea Resources	80	
Grays River	No program.		To be determined[1]
Elochoman River	Elochoman	1,000	300
Skamokawa Creek			
Abernathy Creek			
Mill Creek			
Germany Creek			
Cowlitz River	Cowlitz Salmon	4,480	3,000
Green/Toutle River	N.F. Toutle	1,000	500 interim goal[1]
Coweeman River			
Kalama River	Kalama Falls & Fallert Creek	850 Modrow Trap	400-450 above weir
N.F. Lewis River			5,700
E.F. Lewis River			300
Washougal River	Washougal Hatchery	1,950	3,000
Wind River			500 (100 Tules; 400 Brights)
White Salmon River	Spring Creek Hatchery (Brights)		1,500 (200 Tules; 1,300 Brights)

Chum Salmon management goals for LCMA basins.			
River Basin	**Hatchery**	**Broodstock Goal**	**Natural Escapement**
Chinook River	Sea Resources		
Grays River	Grays Hatchery	360	
Hamilton Creek			
Hardy Creek			
Ives Island	Washougal Hatchery	60	
Duncan Creek			
Lower Tribs			
Winter Steelhead management goals for LCMA basins.			
Cowlitz River	Cowlitz Trout	668 late winters 600 regular winters	6,600
Coweeman River	Coweeman Ponds	Part of Cowlitz production	1,064
N.F. Toutle River	Summer steelhead program only.		
S.F. Toutle River	Summer steelhead program only.		1,058
Green River	Summer steelhead program only.		
E.F. Lewis River	Merwin	400	204
Cedar Creek	No winter program.		698
Kalama River	Kalama Falls	60 hatchery 30 wild	1,000
Washougal River	Skamania	400	841 520 in index area
Salmon Creek	Klineline Ponds		400
Summer Steelhead management goals for LCMA.			
Kalama River	Kalama Falls	50 wilds	1,000
N.F. Lewis River	Merwin	430	
E.F. Lewis River	Skamania		814
Washougal River	Skamania	1,200	1,210
Wind River	No WDFW hatchery program.		957

[1] Lower Columbia Fish Recovery Board and Willamette/Lower Columbia TRT developing goals based on habitat.

Spacial structure is generally a function of habitat size and distribution. Recreational tributary fisheries discussed in the management plan do not affect habitat. The small fishery impact rates estimated also will not reduce population sizes to levels where spacial effects are exacerbated. The estimated small fishery impact rates on natural fish are not expected to exert sufficient selection pressure on any single characteristic to affect diversity. The loss of historic habitat from degradation has contributed to the loss of the spatial integrity of listed salmon and steelhead populations in the LCR ESUs more than any other factor.

As stated above, actions described in the FMEP will not likely affect within- and among-population diversity of the ESUs. The fisheries will not likely impact a certain portion of a run to a greater extent than another. Diversity parameters are most likely influenced by habitat and the effects of natural spawning by hatchery salmon and steelhead. Marked hatchery salmon and steelhead that are caught in the proposed fisheries can be retained, and this can minimize the potential effects of hatchery fish on the diversity of the naturally produced populations. The small, proposed fishery impacts are not expected to affect the diversity of the population by selecting for specific characteristics.

4(i)©) Sets escapement objectives or maximum exploitation rates for each management unit or population based on its status, and assures that those rates or objectives are not exceeded.

WDFW proposes to use interim maximum exploitation rates for tributary fisheries (as described above), with the exception of the NF Lewis River bright fall chinook salmon population, where fisheries will be managed to meet the 5,700 adult escapement goal. WDFW has eliminated the direct harvest of natural adult steelhead and chum salmon in the LCMA fisheries through the use of selective fisheries that require anglers to release all naturally produced steelhead and chum salmon. As described above, selective fisheries have been established for spring chinook salmon in the Cowlitz, Kalama, and Lewis Rivers, where natural spring chinook populations are present. In addition, WDFW has used time and area closures to establish sanctuaries, which are closed to fishing for these species.

Chinook Salmon

WDFW had to rely on other analysis and data to develop appropriate harvest rates for spring chinook salmon. NOAA Fisheries' review of the Pacific Salmon Treaty (PST) discussed appropriate harvest rates for LCMA spring chinook salmon stocks (NMFS 1999). "The three remaining spring chinook salmon stocks within the LCR include those on the Cowlitz, Kalama, and Lewis Rivers. Although some spring chinook salmon spawn naturally in each of these Rivers, the historic habitat for spring chinook salmon is now largely inaccessible. The remaining spring chinook salmon stocks are therefore dependent, for the time being, on the associated hatchery programs. The hatcheries have met their escapement objective in recent years, assuring what remains of the genetic legacy is preserved. Harvest constraints for other stock, including those provided specifically as a result of the agreement, will provide additional protection for the hatchery programs until such time that a more comprehensive recovery plan is implemented

(NMFS 1999)." In 2002, WDFW implemented a selective harvest in the tributary fisheries for spring chinook salmon in the Cowlitz, Kalama and Lewis Rivers and WDFW expects the harvest rate to be less than 10% for these spring chinook salmon stocks. This is consistent with the average annual freshwater harvest rate of Willamette River spring chinook salmon stocks based on population viability analysis and ocean fisheries (ODFW 2000). Since no changes in fisheries management for spring chinook salmon are proposed if the listed populations rebound to healthy abundance levels (i.e., selective fisheries for hatchery fish will continue), harvest rates are not expected to increase beyond the management limits proposed by WDFW.

LCMA fall chinook salmon are differentiated into tule and bright stocks. The only bright stock identified in the Washington portion of the LCR chinook salmon ESU is the Lewis River stock. All other stocks are considered tule stocks. The escapement goal for the Lewis River bright fall chinook salmon was established at 5,700 and based on spawner recruit analysis (McIsaac 1990). Subsequent analysis by Peters *et al.* (1999), which incorporated additional brood years, indicated a similar goal of 5,800. The 5,700-fish goal has been met every year since 1980, except in 1999. The failure in 1999 was believed to be due to the severe flooding in the winters of 1995 and 1996 that limited egg-to-fry survival for these brood years. The tributary fishery will be constrained in all years to allow the 5,700-adult escapement goal to be met.

Tributary fishery management proposed in this FMEP allows for some harvest of fall chinook. These tributary fisheries will be managed to meet escapement goals (Table 2) and the RER for tule fall chinook. Data on LCR fall chinook salmon is insufficient for a formal risk assessment based on population viability analysis. As a result, WDFW has adopted the RER established by NMFS for LCR tule fall chinook salmon fishery impacts that occur in fisheries regulated by the PFMC (NMFS 2002, Simmons 2002). The rebuilding exploitation rate, by definition, does not appreciably reduce the likelihood of survival and recovery of these fish. There are four steps involved with determining population specific RERs: (1) identify populations, (2) set critical and viable abundance levels, (3) estimate population productivity as indicated by a spawner-recruit relationship, and (4) identify appropriate RERs through simulation. The RER for tule fall chinook salmon was set at 49% in 2002 (this is a reduction from 65% used in 2001). As seen with the recent change, the RER is subject to change as new recruitment data is incorporated into the models. The tributary fisheries will be managed according to the most recent RERs determined by NMFS for the PFMC in the North of Falcon process.

NOAA Fisheries developed criteria for the RER for tule fall chinook salmon such that fisheries "will not appreciably increase the number of times a population will fall below the critical threshold and also not appreciably reduce the prospects of achieving recovery (NMFS 1999)." The Coweeman River tule stock has been used as the indicator stock for natural tule populations in the LCR ESU. The majority of freshwater impacts on the tule chinook salmon occur in the mainstem Columbia River recreational and commercial fisheries that are not covered in this FMEP. Combined annual harvest rates in ocean, mainstem Columbia River, and tributary fisheries will be managed not to exceed the RERs determined by NOAA Fisheries for the PFMC.

In the development of the RERs, the assessment explicitly considers the effects of data uncertainty and errors, in addition to the effects of variability in natural mortality rates.

In most of the tributaries where harvest of fall chinook is allowed, the harvest targets returning hatchery fish (Table 3). In the other tributaries included in the LCMA, the retention of chinook salmon is not allowed, though fall chinook may be handled during fisheries targeting coho salmon and steelhead (see Appendix A of WDFW 2003).

To further reduce fisheries impacts on fall chinook salmon, WDFW is supporting the development of selective tributary fall chinook salmon fisheries by working to help develop technologies for mass marking hatchery fall chinook salmon and by securing funding for mass marking while technologies are being developed and implemented.

Table 3. Fall chinook salmon fishing regulations for tributaries in the LCMA. Rivers not listed below are closed to fall chinook harvest (for more detail see Appendix A of the FMEP (WDFW 2003)).

River	Salmon Seasons	Special Regulations
Cowlitz River	Aug. 1- April 30	Area closures from Oct. 1 through Dec. 31 to protect natural spawning.
Deep River	Year around	Targeting net-pen releases.
Elochoman River	Sept. 1 - Dec. 31	Area closures from Oct. 1 through Dec. 31 requires release of all chinook covers most of basin except for short section at mouth.
Green River (N.F. Toutle)	April 1 - Nov. 30	Wild fish release through July 31, and no chinook retention after Oct.1, limiting harvest to the month of Sept.
Kalama River	Year around	Wild chinook release Jan. 1 to July 31 and all chinook release after Oct. 1 except in a short section near the mouth.
Lewis River Mainstem to Forks	Year around	Wild chinook release Jan. 1 to July 31.
E.F. Lewis	Closed	
N.F. Lewis	Year around	Wild chinook release Jan. 1 to July 31. Closed in bright fall chinook spawning area after Oct. 1.
Toutle River and N.F. Toutle River	August 1 to Nov. 30.	South Fork closed, upper section of N.F. Toutle closed after Oct. 1.
Washougal River	Aug. 1 to March 15.	Chinook retention closed after Oct. 1 except in lower ~ 11 rkms.

Chum Salmon

There are limited data to determine appropriate harvest rates for chum salmon in the LCMA. In a meta-population analysis, Myers *et al.* (1999) indicated Ricker α values were around 1.3, which is similar to those observed for Kalama winter steelhead, for which a similar Ricker α is consistent with recovery. Since sustainable exploitation rates are only dependent on the Ricker α parameter, it could then be assumed that the proposed winter steelhead harvest rates (37%) applied to chum salmon would be consistent with recovery. However, to be more conservative, WDFW looked at the 8.3% RER that NOAA Fisheries suggested was appropriate for listed Puget Sound summer chum salmon in the PST analysis (NMFS 1999). WDFW has eliminated the direct harvest of natural adult chum salmon in the LCMA fisheries through the use of

selective fisheries that require anglers to release all chum salmon. In addition, WDFW has used time and area closures to establish sanctuaries, which are closed to fishing for all salmon. WDFW estimates that the harvest rate impact from the incidental catch and release of chum salmon during tributary fisheries targeting other species will not exceed 4%.

Steelhead

Steelhead escapement goals were established in the mid-1980's during moderate- to high- ocean productivity and based on a habitat model developed for the Boldt Case area. Wild steelhead stock escapements have not been monitored for sufficient years in most basins to determine scientifically based escapement goals. As more data become available, basin specific goals will be established through the subbasin planning and TRT processes. Rawding (2001) has calculated extinction harvest rates for summer and winter steelhead in the Kalama River during low ocean productivity using a stock-recruitment analysis (see Figure 2 in FMEP). Extinction harvest rates in this context are defined as harvest from all sources including fisheries, research, and habitat degradation that, if continued, will eventually lead to extinction. For extinction to occur, harvest rates above the threshold must occur for 10 generations or 50 years. These threshold rates were 37% for Kalama summer steelhead and 56% for Kalama winter steelhead. These threshold rates were developed for years of average ocean productivity, but if harvest rates exceed these levels during low ocean productivity for more than a generation, the survival and recovery of the species would be in jeopardy. MSY harvest rates were also calculated during low ocean productivity and these were 22% and 37% for Kalama summer and winter steelhead, respectively. Although the data set did not include a measurement of observational error, WDFW thought that it was low since most fish are trapped at Kalama Falls and others are accounted for by statistical snorkel surveys or jumper counts. Harvest rates would be set well below the 22% and 37% levels observed for periods low ocean productivity. WDFW determined that for these populations, the modeling suggested that the probability of extinction was essentially zero as long as fisheries mortality rates remained less than these levels. The actual harvest rates are expected to be approximately 5%.

For winter and summer steelhead populations below Bonneville Dam, WDFW will manage for an estimated maximum 10% mortality in tributary steelhead fisheries. This is based on expected encounter rates for natural steelhead in the tributary fisheries, the associated catch and release mortality and impacts from non-compliance. This is well below the MSY harvest limits of 22% and 37% that were estimated for Kalama River summer and winter steelhead, respectively. This level of impact is also below the 27% maximum harvest rate that was developed for Oregon steelhead populations by Chilcote (2001) and the management limit of 20% used by ODFW for Oregon steelhead populations in the LCR steelhead ESU.

WDFW also estimated a 10% mortality rate for winter steelhead populations above Bonneville Dam. However, summer steelhead populations from the LCR steelhead ESU that occur above Bonneville Dam are additionally impacted by the operation of Bonneville Dam, fisheries research, and mainstem harvest. Due to these impacts, the WDFW has closed the Wind River above Shipherd Falls (river mile 2) since 1996 and believes harvest impacts on Wind River

summer steelhead should be managed not to exceed 4%. Since no changes in fisheries management for steelhead are proposed if the listed populations rebound to healthy abundance levels (i.e., selective fisheries for hatchery fish will continue), harvest rates are not expected to increase beyond the management limits proposed by WDFW.

4(i)(D) Displays a biologically based rationale demonstrating that the harvest management strategy will not appreciably reduce the likelihood of survival and recovery of the ESU in the wild, over the entire period of time the proposed harvest management strategy affects the population, including effects reasonably certain to occur after the proposed actions cease.

The assessment of impacts from WDFW's LCMA tributary fisheries are described in section 2 "Effects on ESA-listed Salmonids" of the LCR FMEP (WDFW 2003). NOAA Fisheries has also assessed the merits of the FMEP in protecting and recovering the listed ESUs in the Lower Columbia River. Below is a summary of NOAA Fisheries' evaluation of the tributary fishery impacts on spring and fall chinook salmon, chum salmon, and steelhead.

Spring chinook salmon

NOAA Fisheries looked at a number of factors that were instrumental in concluding the FMEP will not appreciably reduce the likelihood of survival and recovery of the LCR spring chinook salmon. First, fishery impacts will be greatly reduced under the selective fishing regime established in the FMEP. Spring chinook salmon harvest rates have averaged 67%, 42% and 30% for the Lewis, Kalama and Cowlitz spring chinook salmon fisheries, respectively, during periods when hatchery fish were abundant (see Figure 4 in FMEP). As these stocks declined in the 1990s, fisheries restrictions reduced harvest. The new selective fisheries for spring chinook salmon will reduce natural spring chinook salmon harvest rates to less than 10% and will generally average closer to 5% (see Table 12 in FMEP).

NOAA Fisheries in the PST Biological Opinion (NMFS 1999) concluded that under the new Pacific Salmon Treaty agreement that overall exploitation rates would decline from the base period (1980-1992 broodyears) but the large terminal harvest incorporated in the analysis would mask the reductions in the ocean fisheries. NOAA Fisheries further identified that spring chinook salmon populations in the LCMA are limited by the absence of suitable habitat so that it was appropriate to manage terminal harvest to ensure that hatchery escapement goals are met. This would protect the remaining genetic legacy of the ESU until future recovery measures are identified. NOAA Fisheries determined that the reduction from the PST agreement would reduce harvest in ocean fisheries and would not likely diminish the chances of meeting the hatchery escapement goals for LCR spring chinook. The selective fisheries for spring chinook salmon are expected to further reduce impacts from harvest in the tributaries or terminal areas, thus further ensuring that hatchery and natural escapement goals are achieved. The 100% marking of all hatchery spring chinook salmon in the Cowlitz, Lewis and Kalama River basins that allows for selective fisheries also allows WDFW to determine the status of the natural

populations in these basins through visual examination of adult spring chinook salmon collected at traps and weirs and from carcasses collected on the spawning grounds.

Another factor that NOAA Fisheries considered was the analysis completed by the Oregon Department of Fish and Wildlife (ODFW) for Sandy River spring chinook salmon in their LCR chinook salmon FMEP (ODFW 2001a). In it, ODFW used a Population Viability Analysis (PVA) that was based on risk assessment survival and recovery likelihoods consistent with those identified in the Upper Willamette River (UWR) spring chinook salmon FMEP (ODFW 2000). The PVA model was used to assess the extinction risk and recovery potential of listed fish under different fishery management regimes using a systematic, biologically based risk assessment model. The model incorporated natural variability in survival at different life stages, ocean harvest, freshwater harvest, stock productivity, and habitat capacity to derive extinction and recovery probabilities. The risk assessment results are conservative because they are based on worst-case productivity assumptions. Actual productivity is probably greater and is expected to continue improving in the future as natural stocks benefit from reduced hatchery influences. The PVA model identified 30% as the impact rate limit for the Sandy River spring chinook salmon rather than the 15% derived for the UWR spring chinook salmon. According to ODFW, "The Willamette limit was less because the Santiam River and McKenzie River populations are subject to significant conversion mortality in the upper Willamette to which Sandy River spring chinook salmon are not exposed. Recent wild fish escapements in the Sandy River were also greater than starting population sizes for upper Willamette populations." Freshwater fishery impacts on Sandy River spring chinook salmon are well below harvest limits of 30% identified by the PVA model. Sandy River spring chinook salmon are the only other natural spawning population of spring chinook salmon in the LCR ESU. The Sandy River natural population has averaged approximately 2,000 adults annually compared to hatchery and natural spawners averaging 342, 185 and 451 spring chinook salmon adults in the Cowlitz, Kalama and Lewis Rivers respectively. Note that spring chinook in these basins are managed primarily to meet hatchery broodstock needs, natural spawning habitat is very limited due to dam construction and other activities. Based on the above information, the proposed fisheries will not appreciably reduce the likelihood of survival and recovery of the listed spring chinook populations in the LCMA.

Bright fall chinook salmon

The escapement objective for Lewis River fall chinook salmon has been established at 5,700 adults based on productivity and habitat constraints (McIssac 1990). This objective was supported by a separate analysis that set the escapement objective at 5,800 adults (Peters *et.al*. 1999). This stock is also a PST indicator stock and is carefully monitored to ensure an adequate escapement. Because this is an indicator stock all fisheries will be managed to ensure that the 5,700 escapement goal is attained annually. In 1998 and 1999 fall chinook fisheries were prohibited in the Lewis River to protect returning adult bright fall chinook from the 1995 and 1996 broodyears that were severely impacted by flooding events in the Lewis River. The escapement goal was achieved in 1998 (5,935) but not in 1999 (3,184). This is considered a healthy fall chinook salmon stock with an intrinsic productivity near 11(McIssac 1990), an

escapement goal of 5,700 wild fish (2001 escapement was 15,000 adults), and has a low number of hatchery spawners. Given these data, it is very likely that this stock is at or will exceeded the Viable Salmon Population thresholds when they are developed by the TRT.

Tule fall chinook salmon

It has been difficult to evaluate the fisheries management regime proposed in the FMEP for the early fall tule stocks of chinook in Washington. Every native tule chinook population of the ESU has been altered from its historic state by hatchery programs, high harvest rates in fisheries, habitat loss, and habitat degradation. Hatchery programs in the Lower Columbia have released large numbers of fish from non-indigenous stocks for over 50 years in most of these rivers. The vast majority of these hatchery fish (>95%) have not been marked so it is not possible to differentiate between hatchery- and natural-origin fish spawning in the tributaries (NMFS 2000b). These hatchery practices have (and continue) to mask the true status of any remnant runs of tule fall chinook throughout the ESU. Lastly, tule fall chinook have been subjected to very high harvest rates in ocean and freshwater fisheries. These fisheries are designed to harvest abundant hatchery chinook and healthy stocks of chinook returning to the Oregon Coast, Washington Coast, and the Hanford Reach of the Columbia River. Because the tule stocks commingle with most of these other stocks, the tules are subjected to intense harvest regimes in these mixed stock fisheries.

The discussion of the above issues is not intended to diminish the importance of conserving and recovering tule stocks throughout the ESU. These populations are listed under the ESA. However, evaluation of the tributary fisheries must be put in the context of the other key factors outside of the scope of WDFW's FMEP. This FMEP is not expected to result in much improvement to the long-term health of the tule chinook populations in the LCR ESU because of the other larger factors, even if all tributary fisheries were closed. Important reforms of hatchery management will have to be accomplished through section 7 consultations between the hatchery operators and NOAA Fisheries. Any changes to harvest management to help protect tules will have to be done via section 7 consultations with PFMC for ocean fisheries and the parties of *US v. Oregon* for estuary and mainstem Columbia River fisheries.

Impacts on tule fall chinook in the tributary fisheries vary substantially depending on the river. Table 3 illustrates the different management approaches for tributary fall chinook salmon fisheries in different basins. In all the other tributaries in the LCMA, retention of fall chinook is prohibited. Tributary harvest of tule fall chinook in the basins in Table 3 are still overshadowed by the harvest in the Lower Columbia River mainstem sport and commercial fisheries. The Lower Columbia River mainstem fisheries are outside the scope of this FMEP. Mainstem fisheries are governed by section 7 consultations between NOAA Fisheries and the parties of *US v. Oregon*.

There are two fishery management regimes proposed in the FMEP for tule fall chinook. The first regime is to prohibit any harvest of wild tule chinook in the tributaries. This is accomplished by prohibiting angling during the period when peak spawning of tules occurs in

the tributaries (Table 3) or by prohibiting any harvest of wild chinook. In these tributaries, fishery impacts on fall chinook populations are non-existent during the fishing closures, or low (likely much less than 2%) because impacts are solely from fish being caught and released.

For those remaining tributaries that allow fall chinook to be harvested, the fisheries will be managed to meet natural spawning and hatchery broodstock escapement goals and to not exceed the RER for tule fall chinook. Data on LCR fall chinook salmon is insufficient for a formal risk assessment based on PVA. As a result, WDFW has adopted the RER established by NOAA Fisheries for LCR tule fall chinook salmon fishery impacts that occur in fisheries regulated by the PFMC (NMFS 2002a, Simmons 2002). The rebuilding exploitation rate, by definition, does not appreciably reduce the likelihood of survival and recovery of these fish. There are four steps involved with determining population specific RERs: (1) identify populations, (2) set critical and viable abundance levels, (3) estimate population productivity as indicated by a spawner-recruit relationship, and (4) identify appropriate RERs through simulation. The RER for tule fall chinook salmon was set at 49% in 2002 (this is a reduction from 65% in 2001). As seen with the recent change, the RER is subject to adjustment as new recruitment data is incorporated into the models, and fisheries will be managed according to most recent RERs determined by the PFMC in the North of Falcon process. WDFW will manage fisheries with the goal of not exceeding the maximum harvest rate (49% in 2002) developed during the PFMC/North of Falcon process for tule chinook salmon stocks in all fisheries. WDFW fall chinook salmon tributary harvest rates are usually less than 10%.

It should be noted that the RER for LCR tule fall chinook salmon is based on the Coweeman River (a tributary to the Cowlitz River) tule fall chinook salmon population. The Coweeman stock of fall chinook salmon is a moderately sized population with a current average escapement of 600 adults but has ranged over the past 10 years from a high of 2,148 to a low of 93 adults. NOAA Fisheries believes that using the Coweeman stock RER for the management of other tule stocks in the ESU is not ideal. The Coweeman stock occupies a relatively small coastal basin, but the population there is moderately healthy and self-sustaining. There is little influence from hatchery fall chinook. This stock is being used as an indicator stock for LCR tule fall chinook salmon because of the long trend in escapement data and because of the minimal influence of hatchery fall chinook salmon spawners. This population may not be representative of all the tule populations in the LCMA but if the RER for the Coweeman fall chinook salmon population is achieved then it can be expected that there would be adequate protection for the other natural tule fall chinook salmon populations. The Coweeman fall chinook population does represent those tule fall chinook salmon populations in the ESU that are not influenced by hatchery fish (i.e., Grays River fall chinook) and are self sustaining. However, it does not represent those smaller tule populations that are not as productive (i.e., gorge tributary populations). For these populations, fisheries impacts on fall chinook salmon are minimized by area closures, modified seasons and limited to impacts from catch and release during fisheries targeting other species. Recovery planning processes will included estimates of harvest impact levels that these smaller populations can sustain while still ensuring recovery.

The approach of using RERs to guide tule fall chinook impacts in the LCMA tributaries appears to be prudent now for the following reasons. The tributaries that allow fall chinook to be harvested are dominated by hatchery-origin returns (Table 3); and the harvest of fall chinook in these tributaries is low and represents far less than 10% of the total harvest in ocean and mainstem Columbia River fisheries.

Chum salmon

Total escapement and harvest estimates are not available for LCR chum and without these it was not possible to establish an RER. Although no RER was identified for LCR chum, WDFW analyzed the 8.3% RER derived by NOAA Fisheries for Hood Canal summer chum salmon (NMFS 2000b). This rate is well below the harvest rate that could be derived if the chum salmon data from the meta-population analysis by Myers *et al.* (1999) was used. WDFW expects harvest impacts on be less than 4% for LCMA fisheries because WDFW has eliminated the direct harvest of natural adult chum salmon in the LCMA fisheries through the use of selective fisheries that require anglers to release chum salmon and through the use of time and area closures to establish sanctuaries, which are closed to all fishing. WDFW estimates that the harvest rate impact will be limited to the incidental catch and release of chum salmon during tributary fisheries targeting other species. This is similar to the impacts on chum salmon expected by ODFW in the Oregon tributaries to the lower Columbia River (ODFW 2001b). Currently, the incidental catch of chum salmon in the Columbia River basin is limited to a few tens of fish per year (NMFS 2002b). The harvest rate in the proposed mainstem fisheries is expected to be 1.6% and is almost certainly less than 5%. The harvest rate in the ODFW proposed tributaries fisheries is expected to be 0.5% and is almost certainly less than 2% (ODFW 2001b).

McClure *et al.* (2000) calculated the population growth rate (lambda) for the Columbia River chum ESU. Lambda values were based on population trends observed in the period from 1980 through 1998 in the mainstem and west fork Grays River, Crazy Johnson Creek, and in Hamilton Creek. They estimated that the lambda value for Columbia River chum populations over this base period was 1.04 indicating that the population levels are increasing and that there is little short or long-term risk of extinction or precipitous decline. Columbia River mainstem harvest rates during the 1980's and early 1990's were greater than current harvest rates (ODFW and WDFW 2000). Furthermore, adult returns in 2001 and 2002 have shown a substantial increase in escapement. Based on these considerations, NOAA Fisheries concludes that the impacts associated with this FMEP are not likely to appreciably reduce the likelihood of survival and recovery of Columbia River chum salmon.

Steelhead

For steelhead, WDFW used a stock-recruitment analysis to define the relationship between spawners and recruits. WDFW used the most conservative assumptions in this spawner recruit model including: (1) using a model with a lowest rate of intrinsic productivity, (2) estimated extinction and MSY harvest rates under the lowest range of smolt to adult survival within the data set, and (3) set harvest rates below MSY, which by definition should be sustainable.

The objective of WDFW's proposed harvest regime is to ensure that harvest is consistent with the recovery of listed populations. To prevent extinction caused by overexploitation, WDFW examined the stock-recruitment analysis for Kalama River winter and summer steelhead stocks, which were the only stocks with sufficient data to conduct the analysis. Walters and Ludwig (1981) demonstrated that measurement error can introduce severe bias into the spawner-recruit relationship. The measurement error associated with the estimates of spawners and recruits is believed to be very low because more than 95% of the winter steelhead escapement estimates are derived from direct trap counts and more than 50% of the summer steelhead escapement estimates are based on trap counts. The remaining escapement estimates, (5% for winter and 50% for summer steelhead) are based on snorkel surveys or jumper counts at the falls (Bradford *et al.* 1996). Reisenbichler (1986) demonstrated that in Monte Carlo simulations, estimates of stock recruitment parameters may be imprecise or biased if age data is unknown. Steelhead do not die after spawning, and scales for age analysis must be collected during their spawning migration at traps or in fisheries. Since wild steelhead harvest fisheries have been reduced since the mid-1980s, the Kalama River is one of the few areas where age data is available. A detailed section of the methods for this analysis may be found in Rawding (2001).

The data was fit with Ricker and Beverton-Holt stock recruitment curves and the results showed a similar goodness of fit. The Beverton-Holt form is sometimes cited (Gibbons *et al.* 1985; Ward 1996; and McGie 1994) as most consistent with the life history of this species, i.e., its extended juvenile residence time in freshwater suggests that density-dependent spawning effects will be of lesser importance than the limiting nature of the freshwater environment. Hence, an empirical relationship between recruits and spawners would be expected to show some asymptotic, maximum recruitment. Barrowman and Myers (2000) found that the Beverton-Holt model generally produced a maximum productivity at low spawning densities that is higher than the Ricker model. If the Beverton-Holt model does overestimate the slope at origin, this may leave managers with a dangerously high impression of resiliency. The Kalama River steelhead data sets, like many other salmon and steelhead data sets, have few data points at a low escapement that are critical in defining the slope at origin in either the Beverton-Holt or Ricker model. Since wild steelhead stocks in this FMEP are listed under ESA, it is critical that managers do not overestimate the intrinsic productivity of the stocks. Therefore, given the similar goodness of fit, WDFW chose the Ricker model because it provided a more conservative estimate of resiliency.

The initial Ricker model fit for summer and winter steelhead was average to good, with R^2 of 0.43 for winter steelhead and 0.65 for summer steelhead. However, WDFW noticed the Pearsons Product Moment Correlation between smolt to adult survival and the number of maiden steelhead recruits produced was 0.83 and 0.66 for summer and winter steelhead respectively (Rawding 2001). Based on this, WDFW added a marine survival parameter to the Ricker model and the improved the R^2 to 0.66 for winter steelhead and 0.83 for summer steelhead. Next, the spawner recruit relationship was examined under the low, average, and high levels of smolt-to-adult return rates in the data set. These are surrogates for the different levels of ocean productivity. Based on this analysis, WDFW developed Ricker α and β parameters for the

different ocean conditions which were used to obtain extinction and MSY fishery harvest rate estimates under various ocean conditions (see Figure 2 of the FMEP).

Recent research has indicated that changes in climate are cyclical, affect ocean productivity, and cause fluctuations in the salmon populations. Andersen (1998) indicated that the five-year average Pacific Northwest Index (PNI), a North Washington coastal climate index, correlated well with the five-year average catch of Columbia River chinook salmon. He indicated that the PNI showed regime shifts in ocean productivity occurred in 1925, 1947, and 1977. This data indicates that cycles of poor ocean productivity lasted about twenty years and are generally followed by a twenty-year period of high ocean productivity. Hare and Francis (1995) demonstrated that changes in Bristol Bay sockeye salmon abundance were correlated with another climate index called the Pacific Decadal Oscillation (PDO) that showed a similar time for changes in ocean productivity. If these two patterns persist for Columbia River steelhead stocks, it would be expected that stocks would have below average productivity for up to 25 years or 4 to 5 steelhead generations followed by 25 years of good productivity. Age structure data indicate the average age at maturity for Kalama River steelhead is 5 to 6 years. Oregon steelhead populations seem to cycle over an 18-year period with nine years of above average productivity and nine years of below average productivity (Chilcote 2001). Under these conditions, steelhead populations may only be at greater risk from low ocean productivity for up to 2 generations.

WDFW's management goal is to establish harvest rates on Kalama River wild steelhead that promote recovery. Since μ_{ext} is defined as the harvest rate that will lead to extinction, harvest rates for recovery must be set below this level. Any harvest rate less than μ_{ext} is by definition sustainable and thus would not appreciably reduce the likelihood for survival and recovery of the listed steelhead. The exploitation rate that maximizes the long-term yield is defined as μ_{msy}. NOAA Fisheries has explicitly recognized the MSY concept in the McElhany *et al.* (2000) and states "Assuming MSY is actually being achieved, a wild population harvested at MSY is, by definition, sustainable (VSP) –provided that the time horizon of MSY is the same as VSP and the MSY estimate takes into account all the factors affecting viability, such as genetic diversity and spatial structure."

WDFW's analysis indicates that the Kalama River summer steelhead stock is less productive than the winter steelhead stock. This may be due to different ocean residency and migration patterns, higher pre-spawning mortality for summer steelhead due to their extended freshwater residence prior to spawning, the differential use of freshwater habitats by these different races, and/or the greater influence of hatchery spawners on wild summer steelhead as compared to winter steelhead. This analysis suggests that Kalama River summer steelhead are at a greater risk of extinction due to their lower intrinsic productivity as compared to winter steelhead.

Since WDFW does not currently forecast wild steelhead runs, they have chosen to use a maximum exploitation rate to manage fisheries such that the fisheries do not appreciably reduce the likelihood for survival and recovery of steelhead under the lowest ocean conditions observed

in the data set. This is a very conservative exploitation rate estimate. For summer and winter steelhead below Bonneville Dam and for winter steelhead stocks above Bonneville Dam, WDFW estimated a maximum harvest rate of 10%, actual harvest impacts are expected to be closer to 5%. However, this level of take in the tributary fishery may jeopardize recovery of summer steelhead populations above Bonneville Dam given the impacts from the operation of Bonneville Dam, fisheries research, and mainstem harvest that affects this population. Therefore, WDFW estimates a 4% maximum harvest rate for summer steelhead in the Wind River during tributary fisheries. For winter steelhead stocks above Bonneville Dam, tributary fisheries impacts will be managed and are estimated to be less than 10%.

Juvenile listed species

Resident trout fisheries. The WDFW has established statewide rules for trout fisheries designed to provide recreational angling while at the same time protecting wild salmon and steelhead populations. Trout fisheries are generally scheduled from June through October in rivers, streams, and beaver ponds, and year-round in lakes, ponds, and reservoirs, unless otherwise specified in Special Rules (see Appendix A to FMEP). Trout fisheries incorporate minimum size restrictions designed to protect juvenile salmonids. There is a two-fish daily limit and an eight-inch minimum size restriction in tributary areas. Mainstem rivers open for trout fishing are regulated to afford additional protection with 12-inch or 14-inch minimum retention sizes applied to the two-fish daily bag limit. All wild steelhead and bull trout/Dolly Varden must be released year-round, except as specifically exempted in Special Rules.

Selective gear restrictions are imposed in areas to promote catch and release opportunities or where fish populations are depressed. Where these restrictions are imposed will vary from year to year, depending on the current status of fish populations. These restrictions allow only the use of unscented artificial flies or lures with one barbless single hook, prohibit the use of bait, and allow fish to be released until the daily limit is retained. Selective gear restrictions also prohibit anyone from fishing from any floating device equipped with a motor, except where specifically allowed under Special Rules for individual waters. Non-buoyant lure and night fishing restrictions are imposed in specific waters to prevent illegal snagging.

Fisheries for resident trout take place in tributaries and standing waters throughout the LCMA. Plants of hatchery-reared trout for put-and-take fisheries have been restricted to standing waters, streams above the anadromous zone, and streams above dams on the Lewis and Cowlitz Rivers. These restrictions are designed to minimize impacts on steelhead and salmon smolts. These plants and fisheries now occur above or in the same reservoirs whose dams block historic salmon migrations. In addition, hatchery-reared sea-run cutthroat trout are released in the Cowlitz River to mitigate for the construction of Mayfield and Mossyrock dams.

Trout fisheries have the potential to impact most listed juvenile salmonids. However, WDFW has implemented time and area restrictions, which greatly reduce potential impacts. The general statewide trout season is open from June 1 to October 31. Trout fishing is closed in the lower Columbia tributaries during the smolt outmigration. WDFW and other agencies operated

juvenile outmigrant traps in LCMA tributaries to determine the timing of the wild steelhead and salmon smolt outmigration. In all years, wild migration increased in April, peaked from late April to mid-May, and is concluded in early June. More than 95% of the wild steelhead and coho smolts had completed their migration by June 1. Although no LCR data is available for spring chinook, the literature would suggest similar or earlier timing. WDFW has five basins open during the spring smolt outmigration, and these include the Cowlitz, Kalama, Lewis, Washougal, and Wind watersheds. In all basins, a substantial hatchery spring chinook salmon or hatchery summer steelhead fishery is present. All are closed to trout fishing and have a 20-inch minimum size limit to eliminate trout fishing during this period.

In addition to the spring closure to protect smolts, WDFW has an eight-inch minimum size and a daily two-fish limit in all streams, with at least a 12-inch minimum and a two-fish limit in larger mainstems. For example, during the 1997 smolt outmigration on the Wind River, 346 of 347 (99.7%) of the wild steelhead smolts handled in Trout Creek were less than the eight-inch minimum size. In addition, all 736 smolts handled in the mainstem Wind River smolt trap were less than the 12-inch minimum and 730 of 736 (99.2%) of the wild steelhead smolts were less than eight inches. Wild steelhead outmigration size and timing are believed to be similar in the remainder of the LCR and current fishing regulations eliminate the direct harvest of wild steelhead juveniles. WDFW estimates that in fisheries targeting winter and summer steelhead that potentially up to 17% of the juvenile steelhead population may be encountered depending on the location and timing of the fishery. The resulting catch and release mortality for those fish handled was estimated to be 2%, thus the fisheries impacts from these fisheries is expected to be less than .5%. Combined with other non-target fisheries harvest impacts are expected to be less than 2% (see Table 12 of the FMEP).

The direct harvest of juvenile salmon is prohibited in freshwater. However, WDFW recognizes that juvenile salmon caught by anglers may be misidentified as trout. As long as anglers follow the eight-inch minimum size for trout, all wild salmon juveniles will be protected from direct harvest. Wild coho and spring chinook salmon smolts remain in freshwater for only one year compared to steelhead that rear for two or three years in the freshwater. Due to this reduced freshwater residency, spring chinook salmon and coho smolts are smaller than the steelhead smolts, and greater than 99% would be less than the eight-inch minimum size used for trout and steelhead protection.

Chum salmon migrate to the ocean shortly after emergence. Peak migration takes place in April when fish are less than 80mm. Fall chinook salmon also migrate to the ocean at age zero but outmigration from tributaries occurs throughout the spring and early summer. The gear that is used by most trout anglers is large enough that only juvenile salmonids greater than (120mm) are recruited into the fishery. This eliminates the likelihood that chum or fall chinook salmon would be caught in the fishery.

Other Resident Fish Species - Fisheries for other species may occur year-round within the LCMA or concurrent with salmon and steelhead seasons. Many of these fisheries, however, are

concentrated after the spring runoff when flows and warm water temperatures permit successful angling. Fisheries occur in the lower sections of some LCR tributaries for warm water game species including largemouth bass, smallmouth bass, channel catfish, crappie, bluegill, carp, and northern pikeminnow. The whitefish fishery is small in the LCR and no specific regulations or special seasons are implemented. Warmwater fisheries also occur in standing waters throughout the basin. Chinook, chum, and steelhead impacts in warm water fisheries are believed to be nil. In the LCR tributaries, warm water fisheries are concentrated in backwaters and sloughs, which are not hospitable rearing areas for juvenile salmonids. Chinook, chum, and steelhead are not present in standing waters where warm water fisheries occur. Fisheries are also most active during warm summer months after spring migrant juvenile chinook salmon and chum have left the system and before fall migrant juvenile chinook salmon disperse downstream from rearing areas. Since warm water species potentially prey on and compete with juvenile salmonids, warm water fisheries could actually provide some marginal benefit for listed salmon and steelhead if the warmwater catch was large enough.

Commercial Carp Fisheries - The WDFW manages the commercial carp fishery as closed unless other wise opened by a WDFW-approved licence request for a fisher. Upon request of a commercial carp license, WDFW will evaluate the potential impacts of the fishery on ESA listed species, the resident biotic populations of the specific water, and cumulative impacts. If the license request is approved, the specific water body is opened to a commercial carp fishery for the license holder. The season for commercial carp fishing is open year-round for license holders. However, the majority of the fishing and catch occur between February and May (S. Jackson, WDFW. pers. comm.).

Gears allowed for use in the commercial carp fishery are trammel and beach seine nets. Applicants must specify which gear type will be used. Trammel nets are required to have an inside net (webbing) with a maximum stretch mesh size of 7 inches, measured diagonally, and a minimum stretch mesh of the outside net (wall) of 12 inches, measured diagonally. Beach seine nets can have a maximum stretch mesh of 2 inches, measured diagonally. While fishing either gear type, nets must be within sight of licensed fisher and must be pulled at least every two hours.

The WDFW regulates the mesh size and duration nets can be set during commercial carp fisheries to limit incidental salmonid by-catch and maximize by-catch survival. The mesh size of trammel nets allows smolt size fish to swim through without impeding passage, while adults are readily captured. The design of the trammel nets holds adult fish by tangling them in the nets by fins, teeth, jaw, or opercle. The opercle are not compressed closed, as with gill nets, and fish can continue to breathe while tangled in the nets. Limiting the duration (two hours) nets can be deployed improves the likelihood for incidentally caught fish to survive after release.

The fishery will be monitored by harvest logs. The WDFW requires all fishers participating in the commercial carp fishery to report total catch of carp and all fish by-catch on harvest logs. The harvest logs are to be returned to the WDFW by the 10th of each month following issuance

of a permit. This is a monthly requirement regardless of fishing activity. Failure to comply with these reporting requirements will result in revocation of current licenses and any eligibility for a commercial carp license for 12 months.

Other anadromous species -Shad fisheries are opened in the LCMA tributaries and the fishery effort is believed to be low. Shad fishing occurs from May through July. The onset of the shad run coincides with the tail end of the spring chinook salmon fishery and the summer steelhead fishery. The impacts are considered with the spring chinook salmon and summer steelhead fishery impacts. The recreational shad fishery is open year-round with no bag limits.

Small sturgeon fisheries occur in the LCR tributaries. However, most of the effort is concentrated in the Cowlitz River. The fishery is generally open year-round and legal sturgeon retention sizes are 42 to 60 inches. Sturgeon anglers fish with bait on the bottom and use very large hooks to catch these large fish. Salmon and steelhead impacts in sturgeon fisheries are believed to be zero.

A smelt fishery occurs in the lower mainstem Columbia River and Washington tributaries. Under permanent regulations, the commercial smelt fishery operates seven days per week from December 1 through March 31 in the Columbia River. However, the season has been reduced or replaced with a test fishery since 1995 because of recent poor returns. Gear includes small otter trawls, gill nets with a maximum of two-inch mesh size, and hand dip nets. This fishery does not affect salmon or steelhead adults or juveniles. Tributary smelt fisheries are limited to dip nets and the most popular fishery occurs in the Cowlitz River. The few adults present during this time easily avoid the gear. Juvenile salmon and steelhead are not migrating at the times and places smelt fisheries occur.

In Table 12 of the FMEP are descriptions of the estimated take of listed fish in various tributary fisheries. The table includes impacts from fisheries including the fisheries targeting con-specific hatchery fish, resident trout and others (whitefish and warmwater species). All these fisheries reflect a wide range of impacts on the various listed species depending on the tributary and the species present, however all these fisheries impacts are below the maximums identified for each of the listed species. Harvest at these rates should support and not appreciably reduce the likelihood of survival and recovery of all the ESUs in the LCMA.

4(i)(E) Includes effective (a) monitoring and (b) evaluation programs to assess compliance, effectiveness, and parameter validation.

Performance indicators for wild LCMA salmon and steelhead include fish population indicators and fishery indicators. Since the objective of this FMEP is to provide fishing opportunity consistent with the recovery of listed species and at rates that do not jeopardize their survival and recovery, the primary indicators for this FMEP are the abundance and productivity of the wild salmon and steelhead stocks.

Section 3 (Monitoring and Evaluation) of the FMEP provides a more detailed explanation of the monitoring programs throughout the LCMA, see also the discussion under the management objectives and performance standards above. The primary fish population indicators for wild salmon and steelhead are spawning escapement estimates in index streams for 3 chum salmon populations, 3 spring chinook salmon populations, 4 summer steelhead populations, 9 winter steelhead populations and 16 fall chinook salmon populations (see Table 13 in the FMEP). In addition, index snorkel reaches are established for summer steelhead, and redd survey reaches for winter steelhead have been established (see Tables 14 in the FMEP). For chum salmon, index streams include the two population centers for this species in the Grays River, and Hamilton/Hardy Creeks and other sites are shown in Table 15 of the FMEP. For fall chinook, index streams include the Grays, Skamokawa, Elochoman, Mill, Abernathy, Germany, Lower Cowlitz, Coweeman, Kalama, NF & EF Lewis, Washougal, Wind Rivers, and Drano Lake (see Table 16 in the FMEP). For other steelhead and salmon population escapements are also estimated annually using redd surveys, mark recapture studies, carcass tagging, snorkel surveys, Area-Under-the Curve (AUC), and trap counts. Juvenile outmigrants are monitored in the Kalama River, NF Lewis River, Cedar Creek, and Wind River.

Performance indicators for fisheries typically include estimates for the catch, catch rates, harvest, harvest rates, hooking mortality for fish caught and released, effort of the fishery, and catch per unit effort (CPUE) for the fishery. WDFW makes statistically based estimates of hatchery steelhead and salmon catch from the WDFW catch record card (CRC) and follow-up phone surveys. Creel surveys are being conducted on the NF Lewis and Cowlitz Rivers for steelhead and salmon to assess hatchery programs. In conjunction with CRC estimates, these can be used to determine the hatchery harvest rate, interception rate for wild fish, and CPUE. Chinook salmon and coho fisheries in major tributaries including the Grays, Elochoman, Cowlitz, Toutle, Kalama, Lewis, Washougal, Wind, and Little White Salmon Rivers are sampled to collect CWT, CPUE, and interception rate for wild fish. Due to lack of funds, these estimates are not available for steelhead fisheries outside of the Lewis and Cowlitz Rivers.

Other monitoring programs that occur outside the LCMA will provide information that may be applicable to these fisheries. For example, it is not possible to monitor the survival of each wild salmon and steelhead that is caught and released. Other studies on gear selectivity and hooking mortality rates by gear, reproductive success of caught and released steelhead and salmon , effectiveness of sanctuary areas, and others would have application in the LCMA. WDFW will make an effort to include this new information when the FMEP is updated or earlier if the information warrants.

In addition to the monitoring programs discussed in the FMEP, there are numerous other ongoing projects funded by other agencies or programs which provide additional information useful for fisheries management. Since freshwater habitats are linked to wild steelhead and salmon production, WDFW monitors habitats through the Salmon and Steelhead Habitat Inventory and Assessment Program and through checks on hydraulic permits. These data may be useful in forecasting salmon and steelhead runs, because they may quantify changes in habitat

productivity, such as, habitat improvement projects that open historic habitats or document nature depensatory processes. Finally, extensive monitoring and evaluation are conducted for chum salmon, chinook salmon, and steelhead at local hatcheries. This program inventories production and returns, tracks straying, monitors fish health, and relates return rates to hatchery practices.

4(i)(F) Provides for (a) evaluating monitoring data; and (b) making any revisions of assumptions, management strategies, or objectives that data show are needed will be made.

As fully explained in sections 3.5.1 and 3.5.2 of the FMEP, WDFW will evaluate the monitoring data on an annual basis. These reports will be provided to NOAA Fisheries and will include biological and fishery information from the previous year and an assessment of how the fisheries performed with respect to the objectives and guidelines established in the FMEP. In addition, a comprehensive review of the FMEP is scheduled to occur after 5 years to evaluate whether the fisheries and natural populations are performing as expected. Comprehensive reviews will be repeated at 5 year intervals thereafter until such time as the natural stocks are recovered and delisted. The comprehensive reviews will allow management assumptions to be further verified and allow new information or findings to be incorporated into the FMEP. This includes the determinations from formal recovery planning efforts and the Technical Recovery Teams.

4(i)(G) Provides for (a) effective enforcement, (b) education, ©) coordination among involved jurisdictions.

The enforcement program is described in section 3.4 of the FMEP. Sport fishing regulations in Washington are enforced by the Enforcement Program of the WDFW. The Fish Management and Enforcement programs work together to develop enforceable regulations to achieve fish and wildlife resource management goals. The Region 5 Enforcement program for the LCR includes one captain, three sergeants, and 13 enforcement officers and is conducted from offices in Vancouver and Cook. They are responsible for enforcement of state fish, wildlife, and habitat regulations in the area covered by this plan. The highest enforcement priority for fish is protection of endangered species, which includes monitoring LCR tributary and mainstem Columbia River fisheries for compliance.

Fisheries are assigned a high priority for enforcement and are intensively monitored. Officers are assigned to work during open fishing days and restrictive seasons, with additional checks during closed periods. Officers conduct bank and boat patrols to check and assist anglers. Covert surveillance is also made in locations where complaints on violators have been received.

The FMEP describes measures that will be taken to inform and educate the public about the fisheries (section 3.3 of the FMEP). The popularity of the steelhead and salmon fisheries result in intense public interest and participation in the annual management processes for these species. WDFW conducts extensive public involvement and outreach activities related to salmon and steelhead fishery management and recovery. The annual fishery regulation process involving a

series of public meetings, information mailouts, press releases, and public hearings was described in detail in section 1.5. Anglers are keenly aware of and accustomed to abrupt inseason management changes including closures and reopenings with short notice. Permanent regulations are detailed in published pamphlets of fishing regulations (see Appendix A of FMEP). Annual regulation and inseason changes are widely publicized with press releases, phone calls or faxes of action notices to key constituents, and signs posted at fishery access points. WDFW also operates an information line, a recorded hotline, and an Internet web page where timely information is available.

4(i)(H) Includes restrictions on resident and anadromous species fisheries that minimize any take of listed species, including time, size, gear, and area restrictions.

The fisheries within the LCMA (section 1.2.1) include many fishing restrictions specifically designed to control impacts on juvenile and adult spring chinook salmon. Section D, above, provides a detailed assessment of angling regulations and the effects on spring and fall chinook salmon , chum salmon and steelhead. These regulations are currently in effect as Washington state law and will remain in effect in the foreseeable future. In the future, if there are proposals to change existing angling regulations, ODFW, will first confer with NOAA Fisheries before adoption, as stated in the FMEP, and in section 223.203 (4)(iii) of the 4(d) Rule for LCR chinook salmon, LCR steelhead, and CR chum salmon.

4(i)(I) Is consistent with other plans and conditions established within any Federal court proceeding with continuing jurisdiction over tribal harvest allocations.

Section 4 of the FMEP describes how the FMEP will remain consistent with federal court proceedings. Tribal fisheries below Bonneville Dam do not currently exist. It is unclear whether any tribes have treaty rights in the LCR tributaries. If the tribes are found to have treaty rights below Bonneville Dam, then WDFW will work with the tribes to develop tributary fisheries consistent with protection of listed species and harvest sharing. Treaty Indian fisheries promulgated by the member Tribes of the Columbia River Inter-Tribal Fish Commission may be conducted in the tributaries above Bonneville Dam. The Yakama Nation currently has fisheries in the Wind River watershed. This fishery is not regulated by WDFW. Each tribe has retained its authority to regulate its fisheries and issues fishery regulations through its respective governing bodies. The tribes are represented by their staff on the Technical Advisory Committee and participate in monitoring activities and data sharing with other parties. The tribes have policy and technical representation in the *U.S. v. Oregon* and PFMC/North-of-Falcon harvest management processes, and coordinate fisheries with the State managers and Columbia River Compact as necessary.

(4)(ii) The state monitors the amount of take and provides to NOAA Fisheries a report on a regular basis.

As described in section 3.5.1 of the FMEP, WDFW will assess compliance with the provisions of the FMEP annually. The runs of spring and fall chinook salmon, chum salmon, and steelhead will be monitored every year and managed to meet objectives of the FMEP. Annual reports which summarize how the previous year's fishery and natural fish runs performed relative to the standards and guidelines specified in the FMEP, will be provided to NOAA Fisheries by March 31st of each year.

(4)(iii) The state confers with NOAA Fisheries on its fishing regulation changes.

As stated in section 3.5.1 of the FMEP, WDFW will confer with NOAA Fisheries on any fishing regulation changes that may affect listed chinook salmon, chum salmon, or steelhead in the LCMA. Information on the proposed regulation change will be provided at least 2 weeks in advance of the decision being made.

(4)(iv) Written concurrence of the FMEP.

If the determination is made that the FMEP adequately addresses all of the criteria specified in limit 4 of the 4(d) Rule, NOAA Fisheries will issue a letter of concurrence to WDFW, which will specify the necessary implementation and reporting requirements.

Processing of the Public Comments Received

As required in (4)(iii) of section 223.203 of the 4(d) Rule, before a FMEP can be approved or amended, the public must have had an opportunity to review and comment on the FMEP. A Notice of Availability and Request for Comment on the LCR FMEP was published on May 29, 2001 (66 FR 29089). No public comments on the FMEP were received by NOAA Fisheries.

RECOMMENDED DETERMINATION

As evaluated above, the Salmon Recovery Division recommends that the Regional Administrator determine that the FMEP for fisheries potentially affecting ESA-listed LCR chinook salmon, LCR steelhead, and CR chum salmon submitted by WDFW adequately addresses all of the criteria established for limit #4 of the 4(d) Rule. If the RA so finds and approves the FMEP, the take prohibitions would not apply to fisheries implemented in accordance with the approved FMEP and NOAA Fisheries' letter of concurrence.

Literature Cited

Andersen, J.J. 1998. Decadal climate cycles and declining Columbia River salmon . In Proceedings of the Sustainable Fisheries Conference. Victoria BC, Canada. 1996. Eric Knudsen editor. Special Pub. American fisheries Society.

Barrowman, N.J., and R.A. Myers. 2000. Still more spawner-recruit curves: the hockey stick and its generalizations. Can. J. Fish. Aquat. Sci. 57:665-676.

Bradford, R.H., S. A. Leider, P.L. Hulett, and C.W. Wagemann. 1996. Differential leaping success by adult summer and winter steelhead at Kalama Falls: implication for estimation of steeelhead spawner escapement. Fish Management Program, Resources Assessment Division Technical Report RAD 96-02. Wash. Dept. of Fish and Wild., Olympia, WA. 56p.

Chilcote, M.W. 2001. Conservation Assessment of Steelhead Population in Oregon. March 5, 2001 Public Review Draft. Oregon Department of Fish and Wildlife, Portland, OR. 83p.

Gibbons, R. G., P.K. Hahn, and T. Johnson. 1985. Methodology for determining MSH steelhead escapement requirements. Report No. 85-11. Fish Management Division. Washington Department of Game. Olympia, Washington.

Hare, S.R., and R.C. Francis. 1995. Climate change and salmon production in the northeast Pacific Ocean, p. 357-372. In R.J. Beamish [ed.] Climate change and Northern Fish Populations. Can. Spec. Publ. Fish. Aquat. Sci. 121.

McClure, M., B. Sanderson, E. Holmes, C. Jordan, P. Kareiva, and P. Levin. 2000. Revised Appendix B of standardized quantitative analysis of the risks faced by salmonids in the Columbia River basin. National Marine Fisheries Service, Northwest Fisheries Science Center. Seattle, Washington.

McElhany, P., M. H. Rucklelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. NOAA Technical Memorandum NMFS-NWFSC-42. Seattle, Washington.

McGie, A.M. 1994. Stock-recruitment in summer-run steelhead of the North Umpqua River, Oregon. Oregon Department of Fish and Wildlife. Report No. 94-5. Portland, Oregon. 30p.

McIsaac, D.M. 1990. Factors affecting the abundance of 1977-79 brood wild fall chinook salmon in the North Fork Lewis River, Washington. University of Washington, dissertation.

Myers, R.A., K.G. Bowen, and N.J. Barrowman. 1999. Maximum reproductive rate of fish at low population sizes. Can. J. Fish. Aquat. Sci. 56:2404-2419.

NMFS (National Marine Fisheries Service). 1999. Endangered Species Act section 7 consultation. Biological opinion on approval of the Pacific Salmon Treaty by the U. S. Department of State and Management of the Southeast Alaska salmon fisheries subject to the Pacific Salmon Treaty. November 18, 2000. Seattle, Washington.

NMFS. 2000a. Endangered Species Act section 7 consultation. Biological opinion on impacts of Treaty Indian and non-Indian year 2000 winter, spring, and summer fisheries in the Columbia River basin, on salmon and steelhead listed under the Endangered Species Act. February 29, 2000. Seattle, Washington.

NMFS. 2000b. Endangered Species Act section 7 consultation. Biological opinion on effects of Pacific Coast ocean and Puget Sound fisheries during the 2000-2001 annual regulatory cycle. Seattle, Washington.

NMFS. 2002a. Revised RER for Coweeman River Natural Tule Fall Chinook. Memo to W. Robinson, assistant regional administrator for sustainable fisheries, from D. Simmons. Seattle, Washington.

NMFS. 2002b. Endangered Species Act section 7 consultation. Biological opinion on impacts of treaty Indian and non-Indian fall season fisheries in the Columbia River basin in year 2002 on salmon and steelhead listed under the Endangered Species Act. August 15, 2002. Seattle, Washington.

ODFW (Oregon Department of Fish and Wildlife). 2000. Fisheries Management and Evaluation Plan. Upper Willamette River spring chinook salmon in freshwater fisheries of the Willamette basin and Lower Columbia River mainstem. Portland, Oregon.

ODFW. 2001a. Fisheries Management and Evaluation Plan. Lower Columbia River Chinook Salmon in Oregon Freshwater Fisheries of the Lower Columbia River Mainstem and Tributaries Between the Pacific Ocean and Hood River. May 25, 2001. Submitted to NMFS. Portland, Oregon.

ODFW. 2001b. Lower Columbia River Chum in Oregon Freshwater Fisheries of the Lower Columbia River Mainstem and Tributaries Between the Pacific Ocean and Bonneville Dam. July 6, 2001. Submitted to NMFS. Portland, Oregon.

ODFW and Washington Department of Fish and Wildlife (WDFW). 2000. Status Report. Columbia River fish runs and fisheries, 1938 -1999. Oregon Department of Fish and Wildlife. Portland, Oregon.

Peters, C.N., D.R. Marmorek, and I. Parnell [eds.]. 1999. PATH decision analysis report for Snake River fall chinook. Prepared by ESSA Technologies Ltd. Vancouver, B.C.

Rawding, D. 1998. A methodology for estimating the adult winter steelhead sportfishing mortality in tributaries to the Lower Columbia River. Wash. Depart. of Fish and Wild. Vancouver, Washington. Unpublished draft, 16p.

Rawding, D. 2001. Stock-recruitment of wild winter and summer steelhead in the Kalama River, Washington. Wash. Depart. of Fish and Wild. Vancouver, Washington. Unpublished draft.

Reisenbichler, R.R. 1986. Use of spawner-recruit relations to evaluate the effect of degraded environment and increased fishing on the abundance of fall-run chinook salmon, *Oncorhynchus tshawytscha*, in several California streams. Thesis, Univ. Wash., Seattle, Washington. 175p.

Simmons, D. 2002. Revised RER for Coweeman River Natural Tule Fall Chinook. Memorandum from D. Simmons to W. Robinson, Assistant Regional Administrator for Sustainable Fisheries. NOAA Fisheries. Seattle, Washington.

Walters, C.J., and D. Ludwig. 1981. Effects of measurement errors on the assessment of stock-recruitment relationships. Can. J. fish. Aquat. Sci. 38:704-710.

Ward, B.R. 1996. Population dynamics of steelhead trout in a coastal stream, the Keogh River, British Columbia. P.308-323 *in* I. Cowx [ed.], Stock Assessment in Inland Fisheries. Fishing News Books, Blackwell Scientific Publications: Oxford.

WDF (Washington Department of Fisheries), Washington Department of Wildlife, and Western Washington Treaty Indian Tribes. 1993. 1992 Washington State salmon and steelhead stock inventory (SASSI). Wash. Dep. Fish Wildlife. Olympia, Washington. 212p. + 5 regional volumes.

WDFW (Washington Department of Fish and Wildlife). 1997. Wild Salmonid Policy, draft environmental impact statement. Olympia, Washington.

WDFW. 2003. Fisheries Management and Evaluation Plan. Lower Columbia River. March 31, 2003. Submitted to NMFS. Portland, Oregon.